Evaluation of MerCAP™ for Power Plant Mercury Control

Quarterly Technical Progress Report

January 1, 2006 – March 31, 2005

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Cooperative Agreement No: DE-FC26-03NT41993

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ABSTRACT

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41993, "Evaluation of MerCAP™ for Power Plant Mercury Control," during the time-period January 1, 2006 through March 31, 2005. The objective of this project is to demonstrate the performance of MerCAP™, a technology that uses a fixed sorbent downstream of wet and dry scrubbers for removing mercury from coal-combustion flue gas. The project is being funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Great River Energy, and Southern Company are project co-funders. URS Group is the prime contractor.

The general concept for MerCAP™ is to place fixed structure sorbents into a flue gas stream to adsorb mercury and then, as the sorbent surfaces become saturated, thermally or chemically regenerate the sorbent and recover the mercury. One example includes parallel gold-coated plates. Mercury forms an amalgam with the gold and is removed from the flue gas flowing past the plates. The captured mercury can be subsequently sequestered using a carbon canister or cryogenic trap during regeneration.

In this project, URS Group and its team are conducting tests at two host power plants to evaluate gold MerCAP™ performance downstream of a spray dryer-baghouse and wet scrubber over an extended period of flue-gas exposure. The spray dryer site, Site 1, is Great River Energy's Stanton Station, which burns a ND lignite coal and a Powder River Basin (PRB) sub-bituminous coal. At this site, an array of gold-coated MerCAP™ plates are incorporated into the outlet plenum of one compartment (6 Megawatt Equivalent (MWe)) of the Unit 10 baghouse. Site 2, the wet scrubber site, is Southern Company Services' Plant Yates Unit 1, which burns an Eastern bituminous coal. An array of gold-coated structures will be configured in a 2800 actual cubic foot per minute (acfm) slipstream (1 MWe) receiving flue gas immediately downstream of a full-scale FGD absorber. MerCAP™ will be evaluated for mercury removal during normal boiler operation for periods of six months at both sites.

MerCAP™ technology has been successfully tested in small-scale units installed at the proposed test sites. Results of this study will verify this performance at a larger scale and over a longer period of gas exposure and will provide data required for assessing the feasibility and costs of a full-scale MerCAP™ application.

During this reporting period, no fieldwork was performed on the site 1 installation, however the economic analysis for site 1 was continued. The MerCAP™ installation at Plant Yates was completed and the unit was put into service. Baseline tests without gold plates showed no influence of the reactor on mercury removal, and the initial results with the gold plates showed good mercury removal. After a couple weeks of run time, the fan used as the motive force for the MerCAP™ unit failed allowing highly acidic flue gas to back up through the reactor and corrode the gold plates. These plates are currently in the process of being replaced and the MerCAP™ will be reconfigured to prevent future failures.

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INTRODUCTION

This document is the ninth quarterly Technical Progress Report for the project "Evaluation of MerCAP™ for Power Plant Mercury Control," (DE-FC26-03NT41993) for the time-period January 1, 2005 through March 31, 2005. The objective of this project is to demonstrate the performance of MerCAP™, a technology that uses a fixed sorbent downstream of wet and dry scrubbers for removing mercury from coal-combustion flue gas. The project is being funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Great River Energy, and Southern Company are project co-funders. URS Group is the prime contractor.

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Great River Energy is providing co-funding and technical support to this project and is providing Stanton Station Unit 10 as a host site. Unit 10 fires North Dakota Lignite and Powder River Basin (PRB) subbituminous fuels and is configured with a spray dryer as a dry FGD system, with a downstream baghouse for particulate control. At this site, an array of gold-coated MerCAP™ plates is incorporated into the outlet plenum of one compartment (6 MWe) of the Unit 10 baghouse.

Southern Company is providing co-funding and technical input to this project and its subsidiary, Georgia Power, is providing its Plant Yates as a host site for testing. Plant Yates Unit 1 fires a low-sulfur bituminous coal and is configured with a small-sized ESP for particulate control, and a downstream CT-121 Jet Bubbler Reactor (JBR) wet FGD system**.** Gold-coated structures will be configured in a 2800 acfm slipstream downstream of the full-scale FGD absorber.

The ability to repeatedly thermally or chemically regenerate exposed MerCAP™ plates is a critical component to the overall economics of the technology. Therefore, during the longer-term tests, small-scale tests are being conducted to evaluate the mercury removal effectiveness at both sites following repeated regeneration cycles. Tests are being conducted using a 40-acfm slipstream probe device ("Mini-MerCAP™ probe"). Gold-coated substrates from the same production batch used for the MerCAP™ arrays in the larger longer-term tests are used in the Mini-MerCAP™ probe.

MerCAP™ technology has been successfully tested in small-scale units installed at the host sites. Results of this study will verify this performance at a larger scale and over a longer period of gas exposure and will provide data required for assessing the feasibility and costs of a full-scale MerCAP™ application.

This report describes the activities carried out for this program during the project-reporting period of January 1, 2005 through March 31, 2005. The remainder of this report is divided into four sections: an Executive Summary followed by sections that describe Experimental Procedures, Results and Discussion, and Conclusions.

EXECUTIVE SUMMARY

Summary of Progress

The current reporting period, January 1, 2005 through March 31, 2005, is the tenth full technical progress reporting period for the project. Efforts during the current period focused on tasks associated with startup of the site 2 MerCAP™ installation.

Site 1 Activities

Field-testing of the MerCAP™ installation at site 1 was completed in March 2005. There has been no further field-testing at site 1. The economic analysis of the site 1 results was initiated during the last reporting period and was continued during this quarter. These results will be reported in subsequent reporting periods.

Table 1 lists the planned and completed milestones for this project.

Table 1. Schedule for Year 1 Milestones for this Test Program.

Milestone	Description	Planned Completion	Actual Start/ Completion
1	Submit Hazardous Substance Plan	Q1	Q1/Q1
2	Submit Test Plan	Q1	Q1/Q1
3	Frame Installation/Baseline Monitoring Site 1	Q1	Q1/Q2
4	Site 1 Gold Installation, Intensive Testing	Q1	Q1/Q3
5	Start of Long Term Testing, Site 1	Q3	Q3
6	End of Long Term Site 1, Gas Char Tests	Q3	Q3/Q2(2005)
7	Site 1 Review/ Site 2 Planning Meeting	Q3	Q4/Q4
8	Frame Installation/Baseline Monitoring Site 2	Q4	Q1 (2006)

Site 2 Activities

Tests at Site 2 will evaluate gold MerCAP™ performance downstream of a wet FGD absorber in flue gas derived from Eastern bituminous coal. The fixed sorbent structure is configured in a flue gas slipstream (approximately 2800 acfm) located downstream of the Plant Yates Unit 1 JBR reactor. The slipstream was originally part of an existing pilot scrubber setup installed previously by Southern Company, however Southern Company decided to remove this scrubber from the host site and instead provide the MerCAP™ with a stand-alone fan. Work during this reporting period included startup of the unit including baseline monitoring and initial performance tests with the gold plates.

Figure 1 is a diagram of the MerCAP system as installed at Plant Yates Unit 1. The test unit reactor was installed in a long horizontal run of pipe that originally ran to the inlet of Southern Company's pilot scrubber. This was previously identified as the best location for the installation.

This location was selected because the MerCAP™ unit could be easily retrofitted into the existing system at this point, and because the run of pipe is relatively close to the ground that will aid in the future sampling activities as well as configuration and installation of the gold plates. A fan that was originally fitted to the pilot scrubber provides the motive force for the flue gas across the MerCAP™ unit. Flue gas exiting the reactor flows back to the Unit 1 duct.

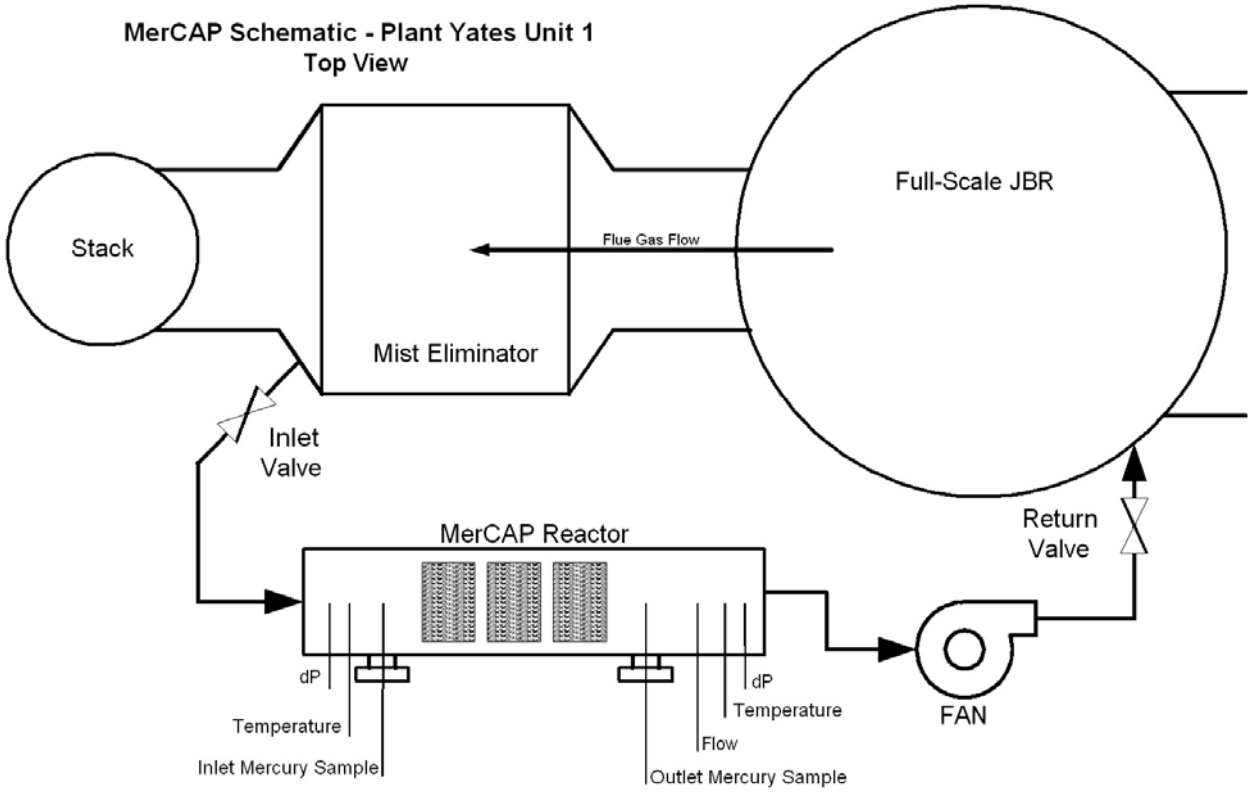

Figure 1. MerCAP™ Installation at Plant Yates Unit 1

The MerCAP™ reactor will be constantly monitored for inlet and outlet temperature, static pressure, pressure drop, and flow. A data logger located on site will continuously collect this data. Ports fitted upstream and downstream of the gold plates will allow access points for mercury measurements, and a wash water system will also be fitted to the system to allow for periodic cleaning of the gold screens.

Sub-Contracts

No subcontracts were awarded during this reporting period.

Task Activity Summary

Table 2 lists the current activity status of the primary tasks for this program. During this reporting period the installation of the MerCAP™ reactor was completed and put into service. Initial baseline measurements were taken to determine the effects, if any, of the reactor itself on mercury removal. The gold plates were then installed, and initial mercury measurements were

made during the first day of operation. The MerCAP™ installation and testing had been delayed at Plant Yates Unit 1 due to a number of factors including competing testing programs and outages. Figure 2 contains a timeline illustrating the various impediments that caused delays, as well as the original planned activities. These delays have been documented in greater detail in previous quarterly reports.

Table 2. Project Activity Status.

Task Number	Description	Planned % Completion	Actual % Completion
1	Project Planning	100%	100%
2	Stanton MerCAP™ Testing	100%	100%
3	Yates MerCAP™ Testing	100%	15%
4	Economic Analysis	80%	50%
5	Project Management & Reporting	85%	60%

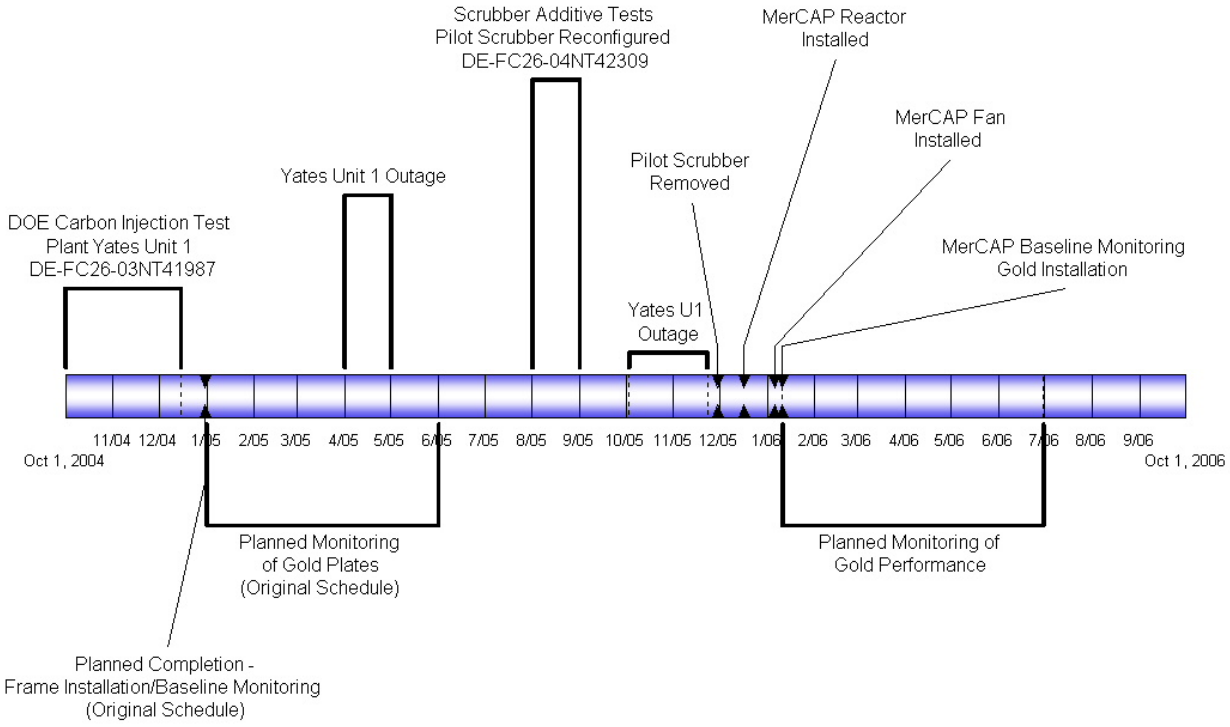

Figure 2. Timeline of Activities and Delays for the MerCAP™ Program at Plant Yates

Problems Encountered

During this reporting period, the MerCAP™ reactor was put into service at Plant Yates Unit 1. A number of problems were encountered with the fan providing the main motive force for the flue gas flow through the unit. When the unit was initially started, the speed control on the variable frequency drive (VFD) seemed to be inoperable, however the flow was able to be controlled through the use of a control valve located just upstream of the fan. The way the

reactor is configured requires that the fan draw gas from downstream of the Chiyoda scrubber at almost neutral pressure, and then return the gas to the duct leading to the inlet of the scrubber that is under positive pressure. A couple of weeks after the initial startup the fan failed and allowed flue gas from the inlet of the scrubber to push back through the system. Because this is untreated gas, it is highly acidic and caused the gold plates to corrode very quickly. Without heated flue gas regularly flowing through the system, the reactor cooled and caused a large quantity of water to condense in the MerCAP™ reactor. Upon inspection of the plates it was determined that they could not be cleaned and would not be suitable for re-use in the reactor. URS and Apogee are currently investigating options for recovering any gold that may be left on the screens.

Since the fan failure, the bearings have been replaced, the shaft has been cleaned and turned, and the motor has been rebuilt. The piping at the inlet of the mercury sampling systems was also corroded and will be replaced. The inertial gas filters remained heated while the system was down and were left unharmed.

Plans for Next Reporting Period

The next reporting period covers the time-period April 1 through June 30, 2006. During this quarter, the MerCAP™ at Site 2 will be cleaned and put back into service. Further evaluation of the instrumentation will determine the components that need to be repaired or replaced. A new set of gold screens will be ordered and delivered to Plant Yates. The cost of these screens will be absorbed into the existing budget. The MerCAP™ system will again be evaluated under baseline conditions without gold plates, and will be run without gold for a period of several weeks while the gold plates are being fabricated. This baseline period will also evaluate the ability of the fan to run for an extended period of time. In order to prevent future failures, a couple of options are being considered including re-plumbing the ductwork to return the flue gas downstream of the scrubber to a location with a much lower pressure, or upgrading/replacing the fan. Once suitable repairs are made, the MerCAP™ will be allowed to run continuously for 6 months.

Prospects for Future Progress

The planned demonstration under the DOE-funded effort at Site 1 is coming to completion. The possibility of continued operation and sources of funding for the MerCAP™ testing at the host site is being investigated. The costs associated with dismantling this system are also being examined. At 5300 hours of operation, 7.3 months of service, the mercury removal performance has been averaging 30% on the original module of gold substrates. The primary detrimental impacts on the technology appear to be spray dryer operating conditions and duct temperature excursions, both of which appear to only have a temporary impact. Additional parametric tests at Site 1 and pending results from Site 2 should help with understanding the mercury gold amalgation process in the presence of flue gas.

The MerCAP at Site 2 will be re-started in May 2006. At that time initial baseline mercury measurements will be made once again across the unit without any gold plates to confirm that there is no impact of the housing and instrumentation on mercury capture or speciation. The

gold plates will then be installed and initial mercury measurements will be made. A series of parametric tests will also be performed to examine the effects of flue gas flow rate.

Due to the delays in the MerCAP™ program at Plant Yates, URS will be requesting a no-cost time extension to this program. The new date for expected completion will be April 30, 2007.

RESULTS AND DISCUSSION

Initial mercury measurements under baseline conditions indicated that the MerCAP™ reactor had no influence on mercury removal. A plot of the data collected during the first couple of days of operation appears in figure 3.

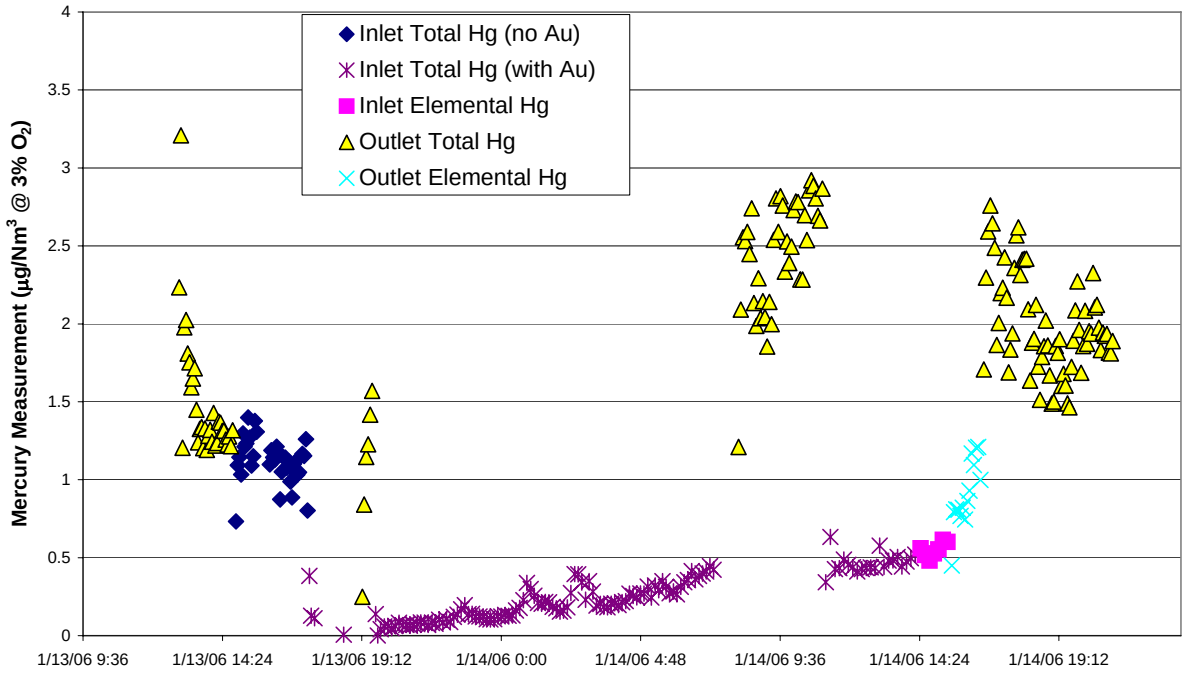

Figure 3. MerCAP™ Mercury Measurements

After the gold was installed the measurements at the "inlet" mercury probe decreased to zero. Mercury measurements at the "outlet" remained consistent with pervious mercury measurements. It was later discovered that the fan was not powerful enough to overcome the pressure at the inlet of the JBR and that the flue gas was traveling backwards through the system even though the fan was spinning. Therefore, the "inlet" measurements are actually downstream of the gold plates and the "outlet" measurements are upstream of the gold and representative of the mercury concentrations entering the MerCAP™ reactor. The initial removal was 100% for the first hour of the test. Over the next 19 hours of operation the mercury removal of the gold plates steadily decreased to approximately 75%. The mercury speciation of the mercury entering the MerCAP™ was approximately 50% oxidized, whereas the speciation of the mercury exiting the unit was +95% elemental.

CONCLUSIONS

Only limited data was collected during this reporting period. Under baseline conditions without gold plates the mercury seemed to be unaffected by the reactor itself. Once the gold plates were inserted, a high level of mercury removal was observed. Even though it has been determined that the flue gas was actually traveling backward through the reactor, the MerCAP™ was able to adsorb between 75% and 100% of the incoming mercury. Unfortunately, the MerCAP™ fan failed shortly after these results were collected causing the reactor to flood and the plates to be destroyed. However, these initial results suggest that MerCAP™ system could be very effective for mercury removal when subjected to flue gas from the outlet of the Plant Yates Unit 1 scrubber.

REFERENCES

No References.